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MONOGRAPH

OF THE

ECHINODERMATA

OF THE

BRITISH TERTIARIES.

BY

PROFESSOR EDWARD FORBES, F.R.S., &c.

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ECHINODERMATA

OF THE

BRITISH TERTIARIES.

INTRODUCTORY REMARKS.

THE remains of Sea-urchins and Starfishes found in the secondary strata of the British Islands, have been sought for with avidity, and made the subjects of numerous memoirs and beautiful illustrations, whilst those that occur in tertiary beds have been treated with undeserved neglect, and are but imperfectly known. The majority of them are undescribed, even unnamed. That they are neither few nor deficient in interest, I shall show in the following Monograph. Unfortunately, a great number of them are known only from fragments. The imperfection of their relics has caused them to be slighted by collectors. Only those gentlemen who have understood their geological importance, have taken the trouble to preserve them. It is to be hoped, however, that since attention will now be called to the interest attached to these fossils, a more diligent search will be made, and both new forms and better specimens of those here recorded, be brought to light. In the present state of the subject, the descriptions of most of the species are necessarily imperfect, and the materials accumulated are not sufficient to warrant, except in a few instances, the construction of a formal diagnosis. I have therefore confined myself to a description as detailed as the specimens at my disposal have admitted.

The marine tertiary of the British Islands can be distinctly divided into two groups, each presenting a general zoological type and *facies*. These are the *Eocene*, and those which succeed it. Under the first are included the Thanet beds and Plastic clays, the London clay and Bognor beds, the Bracklesham beds, the Barton series, and the

superincumbent fluvio-marine strata of Hampshire. Under the second, fall the Red and Coralline Crag, and the series of stratified, unstratified, and drifted deposits of marine origin, constituting the several subdivisions of the Pleistocene or Glacial formation. I regard the Crag, taken together, as stages of older Pleiocene, and the Glacial beds as newer Pleiocene. There is, within our area, a great gap between the Eocene group and the later tertiaries, indicated by the difference of their organic contents. Between the existing fauna of our seas and the oldest stage of the later tertiaries, there is a distinct and extensive relationship of identity of species. Between the later and older tertiaries, there is little or no connection indicated by organic remains.

The list of Echinoderms in our older or Eocene tertiaries is by no means small, and is sure to be increased hereafter. This is evident when we call to mind the fact, that our knowledge of the presence of two most distinct genera is confined to an acquaintance with a few spines of a single species in each, no fragment of the test having as yet been obtained, whilst of others we have found fragments only of the test, and no traces of the spines. Several of our Eocene Starfishes and Crinoids had been previously described, but of our sea-urchins not one had received a name, and only two been slightly noticed. Yet there are nine species, belonging to no fewer than seven genera. Out of all these species only one appears to have been described before, viz. the *Spatangus Onalii* of Galeotti. Out of the seven genera, no fewer than four are types which are not represented in strata of later age than Eocene. These are *Cælopleurus*, *Echinopsis*, *Eupatagus*, and *Hemiaster*. As yet no examples of *Echinolampas*, *Echinocyamus*, *Scutellina*, and *Lenila*, all genera represented not uncommonly in the Eocene strata of France and Belgium, have been found in our British beds. Of the second and third of these genera, the species of which are small and unattractive, I fully expect British examples will yet be discovered.

Of the later Tertiary Echinoderms here described, the majority is derived from the Coralline, or Older Crag. Much interest attaches to them, since we obtain through them a clear indication of some geographical relations of our area during that ancient period. These were distinctly *southern* and *eastern*. This is especially manifested in the presence of *Brissus Scillæ*, still surviving in the Mediterranean, and the relations of the curious and beautiful genus *Temnechinus*, which, though peculiar to the Crag, and at present known only as a group of British Fossils, is closely connected with *Temnopleurus*, *Salmaia*, and *Mespilia*, characteristic genera of the Indo-Pacific region. This relation is also indicated by the Coralline Crag *Crinoidæ*. The affinity of this division of the Crag fauna to the Mediterranean fauna is rather with a portion of the latter, of greater antiquity than the majority of its members, than with the Mediterranean assemblage, as it is at present constituted.

Among the few Echinoderms procured from the Red or Newer Crag, a distinct relationship is maintained with those of the older group, whilst on the other hand, there is manifested a more definite connection with the fauna of the British Seas, as at present constituted.

I have not had occasion to describe any Echinoderm from our Pleistocene Strata. I think, however, it is very probable, that we shall find *Echinus neglectus* in these beds in Britain, even as it has been found elsewhere in beds of corresponding age and origin. Of all the species of its genus, it is the one which ranges most nearly to the North Pole, and is a truly Arctic and Boreal type.

I have to return many thanks to the naturalists who have kindly and readily contributed the materials for this Monograph. For that portion which concerns the Crag, I have especially to thank Mr. Searles Wood, Captain Alexander, Mr. Charlesworth, Miss Alexander, Miss Ransom, Mr. Brown of Stanway, Mr. Bunbury, Mr. Morris, and Mr. Bowerbank.

For that portion which relates to the London Clay, many thanks are due, especially to Mr. Frederick Edwards, Mr. Bowerbank, Mr. Wetherell, Mr. Charles Stokes, and Mr. D'Urban.

Of the greater number of species recorded in this memoir, examples are displayed in the Collections of the Museum of Practical Geology, thanks to the public spirit and liberality of many of the gentlemen whose names I have just recorded. Mr. Edwards has most generously presented the originals of all the species described from his Collection.

EDWARD FORBES.

ECHINODERMS OF THE CRAG.

SUB-KINGDOM. — RADIATA.

CLASS.—ECHINODERMATA.

THERE are Eight Orders of Echinoderms, which, arranged in descending sequence, will stand thus:—

1. SIPUNCULIDEA.	:	5. OPHIURIDEA.
2. HOLUTHURIDEA.	:	6. BLASTOIDEA.
3. ECHINIDEA.	:	7. CYSTIDEA.
4. ASTERIDEA.	:	8. CRINOIDEA.

Of the *Sipunculidea* and *Holothuridea* no species are found in the fossil state, nor, considering the organisation of the creatures composing them, are any likely to be so preserved. The *Blastoidea* and *Cystidea* are exclusively fossil orders, and confined to Palæozoic strata. The *Crinoidea* are for the most part fossil, and chiefly Palæozoic and Mesozoic. The *Echinidea*, *Asteridea*, and *Ophiuridea* are, on the other hand, chiefly Recent, Tertiary, and Mesozoic, and but poorly represented in the earlier strata.

The Echinoderms, of which fossil remains occur in the Crag, are either *Echinidea*, *Asteridea*, or *Crinoidea*: chiefly members of the first order. It is quite possible that, many species of star fishes and of brittle stars (*Ophiuridea*) lived in company with them, although, owing to their excessive fragility, no remains are preserved to us.

ORDER.—ECHINIDEA.

The Echinoderms of this order are distinguished by their regular plated test, investing the entire body with a coat of mail. They have always two digestive orifices. Their ambulacra are always embodied in the test, and divide it into segments. Their genital orifices are placed in the centre of peculiar plates, which form an apical disk, usually in

conjunction with the plates bearing the eyes. These latter are always at the superior termination of the ambulacra. They move by suckers, which are extended from the ambulacral pores, and assist themselves in their movements by spines, which are articulated to tubercles projecting from the surface of the plates of the test.

Family.—ECHINIDÆ.

Three of the families of the Sea-Urchins are distinguished from all others, in having their anal orifice placed in the centre of the genital plates, and directly opposite to the mouth, which occupies the centre of the ventral surface. Of these groups, the *Palæochinidæ* are peculiar to Palæozoic strata; the *Cidaritidæ* and *Echinidæ* range from the commencement of the Mesozoic epoch to the present day. No *Cidaris* has, as yet, occurred in the British Crag. In the collection of Sir Charles Lyell are the spines of a very distinct species from the Black Crag of Antwerp. The *Echinidæ* are distinguished by their developed ambulacral areas, always bearing some or many primary spines, and by their rows of pores ranged in more or less distinct ranks.

Genus—ECHINUS, *Linnæus*.

Body more or less spherical; ambulacral and interambulacral segments developed, bearing on their plates, which have entire margins, tubercles of various sizes; vent central, not furnished with regular calcareous valves, but surrounded by a membrane covered more or less with irregular ossicles. Genital disk surrounding the anal space, and composed of five genital and five ocular plates, all perforated and alternating; one of the former combined with a madreporiform tubercle; ambulacral avenues composed of pairs of pores, ranged in series of three or more, always distinctly ranked near the mouth; spines of one order.

All the species of *Crag Echini* belong to the typical section of the genus, that in which the pores are ranged in ranks of three pair in each. Such forms are, at present, pre-eminently of Atlantic types. It is remarkable, that none of the common British species of this genus can be identified with those found in the Crag.

1. ECHINUS LAMARCKII. Plate I, fig. 4.

Very reluctantly, I feel obliged to designate, by a new name, the commonest of sea-urchins found in the Coralline Crag. It is very closely allied to *Echinus sphaera*, the most abundant species in the Celtic province of the Atlantic; so nearly, indeed, that not until after considerable hesitation, did I feel constrained to regard it as distinct. It differs

essentially, in a minute character, which is constant in all the numerous examples submitted to my examination; viz., in the presence of a minute granule separating the pores of each pair. Otherwise, it differs in presenting more prominent bosses upon which the spiniferous tubercles are placed, and in the more irregular dimensions of these organs. The base has constantly a tendency to concavity, not seen in *Echinus sphæra*. At the same time, I believe it to be a variety of another and rarer British species; one communicated to me from the Coast of Cornwall by my friend Mr. Peach, and described at the British Association at Edinburgh, in 1850, as a form of *Echinus melo* of Lamarek. It would appear, however, that under the name of *E. melo*, Lamarek confounded two very distinct species, and that the true *E. melo* is that enumerated under the same name by Agassiz and Desor, a Mediterranean species, which (after an examination of the original examples in the collection of the Jardin des Plantes,) does not seem to me to differ essentially from the *Echinus Flemingii* of the British and Norwegian Seas. It results that a new name must be given to the species before us, whether it be considered strictly identical with the Cornish (and Mediterranean also) sea-urchin alluded to before, or be regarded as an extinct form, as yet peculiar to the epoch of the Coralline Crag.

Body varying in convexity, a slightly depressed spheroid swelling out below; in some specimens obscurely pentangular, divided into five broad (or interambulacral) and five narrow or ambulacral segments, separated from each other by avenues of pores, which are arranged in oblique rows of three pair in each row. Towards the middle of the sides, the breadth of an interambulacral segment, as compared with an ambulacral, is as 5 to 2. All the plates are thickly covered by tubercles, of which the primaries are slightly unequal in size. The tubercles are round, imperforate, and placed on the summits of broad, gradually swelling bosses. The interambulacral plates are very broad in proportion to their height. The broadest of them bear about nine primary tubercles, which are arranged in one single and one half row, the latter towards the truncated or ambulacral end of each plate. There are about two large primaries on each ambulacral plate, the smaller ones innermost. Towards the superior extremities of the ambulacral avenues one row only becomes prominent. Among the primary tubercles are a few secondaries and many miliary granules. Between the two pores of a pair, there is usually a miliary granule. The oral aperture is one third broader than the apical disk, and occupies about one third of the breadth of the entire test. It is placed in a slight concavity, and its margin is gently indented by notches, with reflexed margins at the interambulacral sides of the avenues. The apical disk is not preserved in any of the specimens which I have examined. Internally, the pores of the avenue appear widely disjoined, and those next the ambulacral segments are larger than the opposite ones.

The spines are stout, but not very short. They are finely grooved, with numerous narrow sulci, the interspaces being smooth, and slightly convex.

A good example measured two inches and two tenths in height by three inches in breadth.

Fine specimens from the Coralline Crag of Sutton, &c., have been communicated by Capt. Alexander, Mr. Brown of Stanway, Mr. Searles Wood, and Mr. Bowerbank. This species is preserved in most collections; and specimens presented by the three first-named gentlemen are exhibited in the collections of the Museum of Practical Geology.

2. ECHINUS MELO? Plate III, fig. 10.

ECHINUS MELO, *Lamarck*. Anim. sans Vert., vol. iii, p. 45.

— — *Agassiz*. Monog. Echin. Anat. Echinus, p. iii.

— — *Agassiz and Desor*. Ann. Sc. Nat., 3d series, tom. vi, p. 365?

Mr. Searles Wood has communicated the remains of a remarkable urchin of considerable dimensions, which appears to be distinct from any I have seen from the Coralline Crag, whence it is derived. The fragment exhibits a considerable number of the plates of the dorsal surface, with well-preserved portions of two of the avenues. The plates bear few and scattered tubercles, mingled with few and scattered granules. One of the tubercles is slightly larger than the rest, on each plate. The pores are ranked in triple series, ranged at a slight angle of obliquity, and each rank set further apart from its neighbour than is usual. These arrangements approach so nearly to those I have seen in some examples of the true *Echinus melo*, that until more perfect specimens of the fossil are met with, I place it provisionally under that species.

3. ECHINUS LYELLII. Plate I, fig. 5.

Body a convex, and rather elevated spheroid. Interambulacral areas (centrally) to ambulacra, as 5 to 2. Ambulacral plates, each with a single primary tubercle, and, towards the base, a small secondary one, so that the ambulacral segments are distinguished by the presence of two very regular, rather distant rows of nearly equal close-set tubercles. From the outer or avenue-side of their bosses proceed three radiating ridges to separate the pairs of pores in the avenues. The interambulacral plates are rather high (for the genus) in proportion to their breadth. Each bears from one to three primary tubercles, of which the centre one is largest, (but all are rather small,) and a few scattered miliary granules. The tubercles appear few, in proportion to the extent of the interambulacral spaces, and the larger ones fall into rows, but not so conspicuously marked as the ambulacral rows. The pores are arranged in oblique series of three pairs in each, each pair separated from the others by the radiating ridges already mentioned. The apical disk appears to have been small in proportion to the size of the body. The mouth and under surface has been destroyed. The spines are unknown.

The only specimen (an imperfect one,) of this very distinct urchin which I have seen, measures $\frac{1}{4}$ ths of an inch in height. Although a fragment, it is in good preservation. It was discovered, by Mr. Wood, in the lowest part of the Coralline Crag, at Ramsholt.

4. ECHINUS HENSLOVII. Plate I, fig. 7.

Body a sub-depressed spheroid. Ambulacral areas to interambulacral, as 1—2. Plates of both areas thickly covered by small depressed granules and tubercles, disposed in an obscurely radiating arrangement around a somewhat larger central tubercle. The smaller tubercles densely crowded along the sutural lines. Pairs of pores disposed in oblique rows of three pair becoming less oblique, and almost falling into line near the apical disk. Apical disk rather large in proportion to breadth: its plates, in the only specimen I have seen, are wanting. The under side of this example is entirely concealed. Breadth, $\frac{7}{12}$ ths of an inch; height, $\frac{4}{12}$ ths of an inch.

A single specimen, in the cabinet of Mr. Searles Wood. It is from the Red Crag of Walton.

It is very nearly related to the *Echinus Martinsii*, an unpublished species, from Iceland, preserved in the Museum of the Jardin des Plantes.

5. ECHINUS CHARLESWORTHII. Plate I, fig. 6.

ARBACIA, species of, *Searles Wood*, MS. in *Morris*, Cat. Brit. Foss., p. 48.

Body nearly globose, with slightly tumid segments and impressed avenues; the former, thickly studded by minute crowded, nearly equal tubercles. The pairs of pores are arranged in moderately oblique rows of three in a series. Between each pore of a pair the ridge is slightly elevated, and here and there, upon the avenues, are minute granules. The ambulacral plates bear each from three to five minute, globular, primary tubercles, elevated upon narrow bosses, and differing but slightly in their dimensions. Between them are thickly scattered granules. The interambulacral plates are very broad in proportion to their height, and bear from nine to twelve primary tubercles, of which three or four on the avenue-side of each plate are slightly larger than the others, and ranged more regularly in a slightly oblique row, giving a somewhat undulated aspect to the sides. The apical disk, which is destroyed, appears to have been small in proportion to a rather large mouth. The finest specimen measures $\frac{1}{12}$ th of an inch in diameter by $\frac{1}{12}$ th of an inch in height.

I know no existing sea-urchin which can be compared with this pretty species. It is from the Coralline Crag of Ramsholt.

Genus—TEMNECHINUS, *Forbes*.

Body more or less spherical; ambulacral and interambulacral segments developed, bearing on their plate, whose sutural margins are mostly excavated, tubercles of various sizes; vent central. Genital disk surrounding the anal space composed of five

prominent) genital and five ocular plates all perforated, and alternating; one of the former combined with a madreporiform tubercle; ambulacral avenues composed of pairs of pores indistinctly ranked; their ranks confluent throughout. Spines of one order.

The urchins for which I have constituted this genus differ from *Temnopleurus*, to which the best known species has been referred, in having the bosses of the tubercles plain, and not crenulated; in having no pores at the angles of the plates, and confluent instead of ranked series of sucker-pores throughout the length of their avenues. The last two characters also distinguish them from *Microcyphus*, as well as (with the first character) from *Salmaeis*. They fill up the interval, in fact, between *Echinus* proper and the group of allied genera, with pores, as well as excavations at the angles of their plates.

It is remarkable that, as yet, no existing sea-urchin can be referred to this genus; nor are any species recorded from extra-British localities.

All the known sea-urchins having notched plates are inhabitants of tropical seas, and appear to belong almost exclusively to the Indo-Pacific province. The fossil species of the genera mentioned above are all Tertiary. They belong to *Salmaeis* and *Temnopleurus*. Two species of the former genus are recorded as European fossils, one from the Nummulitic limestone, and one from the pliocene of Palermo.

The *Temnechini* are remarkable for their beauty, as well as for their rarity.

1. TEMNECHINUS EXCAVATUS. Plate I, fig. 1.

TEMNOPLÉURUS EXCAVATUS, *S. V. Wood*, MS. in *Morris*, Cat. Brit. Foss., p. 60.

— WOODII, *Agassiz*. Cat. Rais. des Echin., in Ann. Sc. Nat., 3d series, tom. vi, p. 360.

TEMNECHINUS EXCAVATUS, *Forbes*. Fig. and Desc. Brit. Org. Rem. Dec. IV, pl. i.

The general form of this beautiful urchin is a depressed melon-shape, hollowed out above. The interambulacral segments are, centro-laterally, twice as broad as the ambulacra; the sutural pits of their dorsal surface are transversely oblong, very deep, and completely confluent, so as to appear like profound undulated furrows with steep sides; centro-laterally, the pits become smaller and disjointed, and decrease gradually in dimensions and depth towards the margin of the mouth. The interambulacral plates bear on their elevated portion each a primary tubercle, seated on a proportionately small but prominent smooth boss, and surrounded by granules, those on the dorsal plates being very numerous, and collected on a tumid surface; those on the ventral being fewer, and interspersed among small secondary tubercles, which form rings round the primaries. Of the latter, there are about ten in each half of an interambulacral space, and a like number of sutural pits. The sutural pits of the ambulacral segments are shallow, and partially confluent above. Each ambulacral plate bears near its outer or ambulacral margin a primary tubercle, equal in size to those of the interambulacra, and round this, both dorsally and ventrally, are set secondary tubercles, interspersed with granules. There are

about sixteen primary tubercles, ranged in a regular row, in each half of an ambulacral segment. The mouth is rather small in proportion to the diameter, but is larger than the genital disk. It is obscurely decagonal. The genital disk is very prominent. The five genital plates are pentangular, very tumid, and steep-sided: their sides quite smooth and excavated; their summits coarsely granulated, with two or three small secondary tubercles on their inner edge, bordering the anus. The genital pores are at the projecting angles of the plates, at their lowest and smoothest part. The eye plates are pentangular and smooth, except in the centre.

The dimensions of a fine specimen are $\frac{1}{12}$ ths of an inch in breadth by $\frac{1}{12}$ ths of an inch in height.

Spines apparently belonging to this species are short and stout, rapidly tapering, and grooved by about twelve rather strong and deep sulcations. The neck of the spine is surrounded by a ring of very strong crenulations.

Fine specimens from the Coralline Crag of Ramsholt are contained in the cabinets of Mr. Searles Wood, Mr. Charlesworth, and that of the Museum of Practical Geology.

2. TEMNECHINUS MELO-CACTUS. Plate I, fig. 2.

This species is equally beautiful with the last, from which it differs conspicuously in its less depressed shape, the defined and not confluent sutural pits of its upper surface, the sloping sides of the genital plates, and the more equal dimensions of the secondary tubercles.

Its general shape is a depressed, but not flattened or hollowed out spheroid, with tumid but not bulging sides. The interambulacral segments are (centrally) to the ambulacrals as 3 to 2. The sutural pits of their dorsal surfaces are strongly marked, but not so deeply hollowed out as in *T. excavatus*. They alternate regularly, and are not confluent, except very slightly so immediately near the apical disk. The pits preserve their dimensions and arrangement centrolaterally, and only become obsolete in the immediate neighbourhood of the mouth. The interambulacral plates bear on their elevated portions each a conspicuous and prominent, but not large, smooth, primary tubercle, smaller in proportion to the size of the plate, than those in the last species. It is nearly surrounded by secondary tubercles and granules, rather scattered, and most of the former nearly equal in size. These are similar on both ventral and dorsal surfaces. There are about ten primaries in each vertical row, and a like number of sutural pits. The sutural pits of the ambulacral segments, and of the interambulacral avenue-margins, are shallower, smaller, and the former more numerous. They are all distinctly defined, and not confluent. Each ambulacral plate bears on its outer half a primary tubercle nearly equal to that on an interambulacral plate, and similarly surrounded by secondary tubercles and granules. There are about fifteen of the ambulacral primaries in each vertical row. The pairs of pores in the avenues are very obscurely three-ranked, and similar in

disposition throughout; they are separated from each other by elevated ridges, and here and there a scattered granule. The mouth is much larger than the vent, and is obscurely ten-notched. The genital disk is prominent and tumid, but not abruptly sided. The flattened and prominent portion of each genital plate is covered with slightly unequal secondary tubercles or granules; its inferior and declining margin, with the space about the genital pore, is smooth. One of the genital plates bears obscure traces of the madreporiform tubercle. The ocular plates are pentagonal, and slightly rugose.

I have seen three specimens of this species, all of different sizes, from the Coralline Crag of Ramsholt. It is contained in the collection of Mr. Searles Wood. The largest example is $\frac{1.0}{12}$ ths of an inch in breadth by $\frac{7}{12}$ ths in height.

A single remarkable and exceptional specimen of a *Temnechinus*, larger even than the above, exhibits some striking differences, presenting the general shape of *T. excavatus*, with most of the characters of *T. melocactus*, of which, for the present, I must regard it as a variety.

3. TEMNECHINUS GLOBOSUS. Plate I, fig. 3.

This species, also from the Coralline Crag of Ramsholt, differs from the preceding in being of a globular form, having much smaller and less conspicuous sutural pits, and smaller, more numerous, and more equal tubercles. It approaches much more nearly to a true *Echinus*.

The test is very convex above, and the sides elevated and gradually rounded. The interambulacral segments are, in breadth, centrally to the ambulacra nearly as 3 to 2. The sutural pits are shallow, confined, and placed well apart: those on the ambulacral segments are much the smaller. They all become gradually obsolete on the lower half of the test. Each plate, whether ambulacral or interambulacral, bears a small primary tubercle, surrounded by minute secondaries and intermediate granules. There are twelve primaries in each interambulacral, and fifteen in each ambulacral vertical row. The avenues of pores are nearly straight, the ridges between the pairs of pores strongly marked. The mouth exhibits very slight traces of notches. The genital plates are wanting in the two examples which I have examined. The larger specimen measures half an inch in height by eight twelfths in breadth.

4. TEMNECHINUS TURBINATUS. Plate III, fig. 11.

TEMNOPLEURUS, species of *S. V. Wood*, MS. in *Morris*, Cat. Brit. Foss., p. 60.

The only example of a *Temnechinus*, from the Red Crag, is one from Sutton. It is contained in the cabinet of Mr. Searles Wood, who long since called attention to its existence.

It is a worn specimen, much rubbed, but differs so markedly in several respects from

its congeners, that it must be regarded as distinct. The form is a depressed, but not lobed spheroid. The genital disk is less prominent, and smaller, than in the other species of the genus. The genital plates seem to have been decorated by fewer tubercles. The ambulacral segments are half the breadth of the interambulacral divisions. The sutural pits are defined, rather small, and not confluent. The primary tubercles on both ambulacral and interambulacral are much larger than in the other *Temnechinini*, and surrounded by wider areolæ. There are about ten interambulacral, and thirteen, or so, ambulacral tubercles in a vertical row. The pores are arranged as usual. The specimen described measures half an inch across by rather more than a quarter of an inch in height.

In Mr. Morris's 'Catalogue of British Fossils,' a *Salenia* is mentioned as occurring, on the authority of Mr. Searles Wood, in the Coralline Crag of Sutton. The specimen alluded to has been submitted to my examination, and proves to be an immature sea-urchin, apparently the fry of one of the species of *Temnechinus*. The plates of the genital disk exhibit an appearance of pitting and rugosity which is anomalous, and strongly resembles at first glance the sculpture of the plates of *Salenia*. Hence the mistake about its generic position. There is, however, no supplementary plate, as in that genus. The traces of pits at the angles of the plate distinctly indicate its affinities with *Temnechinus*. Otherwise it might, with its large disk, have been considered a young *Goniopygus*.

Family.—CLYPEASTERIDÆ.

The urchins of this family are more or less rounded, often ovate, generally depressed. Their shells are thick, and frequently strengthened within by calcareous buttresses. Their mouths are central; their vents eccentric. They are provided with a dental apparatus of more simple structure than that characteristic of the *Echinidæ*. Their ambulacra are either distinctly petaloid and convergent, or, as in the examples about to be described, are sub-parallel. They have five genital and five ocular plates, but these are not all perforate in every case. The species found in the Crag are, with doubtful exceptions, all of the same genus with the representative of the family in the British Seas at present.

Genus—ECHINOCYAMUS, Von Phelsum.

Body depressed, ovate or sub-orbicular, with ambulacra which are sub-heterogeneous, their dorsal portions forming pseudo-petals with nearly parallel or slightly diverging avenues. Test thick, and strengthened within by ribs; its surface covered with small and similar tubercles, which bear rather short slender spines. Mouth round, and sub-central or central. Vent inferior. Four genital pores. A dental apparatus arming the mouth.

The species of this genus are all small, and difficult to distinguish. Almost all are tertiary. A few are found existing.

1. *ECHINOCYAMUS PUSILLUS*. Plate I, figs. 8—15.

SPATANGUS PUSILLUS, *Muller*. Zool. Dan., p. 18, tab. xci, figs. 5, 6.

ECHINUS MINUTUS, *Gmelin*. Linn., p. 3194.

ECHINOCYAMUS MINUTUS, *De Blainville*. Man. d'Actin., p. 214.

— *ANGULOSUS*, *Leske* ap. Klein., p. 215.

— — *Agassiz*. Mon. des Scutelles, p. 130, tab. xxvii, figs. 17, 18.

ECHINOCYAMUS ANGULOSUS, *Agassiz* and *Desor*. Ann. Sc. Nat., 3d series, tom. vii, p. 140.

— — *Duben and Koren*. Kong. Vet. Akad. Hand., 1844, p. 279.

FIBULARIA ANGULOSA, *De Blainville*. Dict. Sc. Nat., tom. xvi, p. 512.

— — *Lamarck*. An. sans Vert., vol. iii, p. 17.

— — *Desmoulins*. Tab. Syn., p. 236.

ECHINOCYAMUS PUSILLUS, *Fleming*. Brit. Anim., p. 481.

— — *Forbes*. Brit. Starfishes, &c., p. 175, (fig.)

— — *Agassiz*. Mon. des Scutelles, p. 128, tab. xxvii, figs. 1—5.

FIBULARIA TARENTINA, *Lamarck*.

ECHINOCYAMUS TARENTINUS, *Agassiz* and *Desor*. Ann. Sc. Nat., 3d series, tom. vii, p. 140.

This very common, widely distributed, and very variable little urchin, is an abundant fossil in the Red Crag, especially at Alderton, Suffolk, assuming numerous changes of form, all however distinguished with facility by the position of the anus half way, or nearly so, between the mouth and the posterior margin, and by the coarse and rather conspicuous tubercles of the surface. The avenues of pores are sub-parallel, and slightly radiating. The margin is always more or less tumid, and sometimes almost swollen. The mouth is large, round, and conspicuous. The vent is also large. The exterior is strengthened by strong buttresses. In the living state, the test is covered with thick-set minute squamated spines, turning of a powdery-green colour, as the animal dies.

The principal varieties, all of which, however, pass into each other, are the following :—

a. Normalis, regularly oval, and tumid, (Pl. I, figs. 8—13.)

b. Rotundus, nearly orbicular, and tumid, (Pl. I, fig. 15.)

c. Depressus, rounded or ovate, much compressed above.

d. Angulosus, approaching an ovato-pentagonal shape, (Pl. I, fig. 11.)

e. Triangularis, sub-triangular, and sometimes curved, (Pl. I, fig. 10.)

f. Tumidus, ovate, and much swollen.

The last two forms are rare. All variations of shape between nearly completely circular, and narrowly ovate, may be taken in the one locality at the present day. A rather large

fossil example measured five twelfths of an inch in length. The breadth and height vary according to the variety.

2. ECHINOCYAMUS SUFFOLCIENCIS. Plate I, fig. 16.

FIBULARIA SUFFOLCIENCIS, *Agassiz*. Prod., p. 188.

— — — *Desmoulins*. Tab. Syn., p. 244.

ECHINOCYAMUS SUFFOLCIENCIS, *Agassiz*. Monog. des Scutelles, p. 129, tab. xxvii, figs. 9—13.

— — — *Agassiz and Desor*. Ann. Sc. Nat., 3d series, vol. vii, fig. 141.

The distinguishing features of this species are its compressed margin and the sub-marginal position of the very small vent. The tubercles of its surface, though coarse and conspicuous, and similarly set in deep areolæ, are slightly smaller than those of *E. pusillus*.

There are two well-marked varieties :—

a. The test of this form is broadly sub-pentagonal, much depressed, flattened out towards the margins, sub-rostrated anteriorly, hollowed out slightly beneath, and has the mouth slightly sub-pentagonal. This is the larger variety. It measures as much as four twelfths of an inch in length by three tenths in breadth, and one eighth in height.

b. The test is ovate or elongate, rather more tumid, with a round and proportionately larger mouth. The largest specimen observed, measures three twelfths of an inch in length by two tenths in breadth and one twelfth in height.

Both are found in the Red Crag of Walton on the Naze.

The description given by Agassiz does not touch upon the remarkable position of the vent, and is very insufficient. He states, that it comes very near *E. pusillus*, but differs in its more depressed, and broader, and more circular shape. He notices the smaller tubercles. His figure is not characteristic, and apt to mislead. It represents a specimen of the smaller variety, but the position of the vent is exhibited much too far from the margin. Since this distinguished naturalist named the specimens in Mr. Wood's cabinet, there can be no mistake about which he meant. I mention this, because the name *Suffolciensis* seems to be applied to another species in the 'Catalogue of British Fossils.'

3. ECHINOCYAMUS HISPIDULUS. Plate I, fig. 14, *a*, *b*, and *c*.

This very distinct species is more or less sub-orbicular, or sub-pentagonal, much depressed, variably convex above, usually tumid at the margins, and slightly concave in the region of the mouth. The entire surface is covered with very minute tubercles and granules, so as to give it a hispid appearance to the naked eye. The boundaries of the plates are indicated by very distinct groovings. The ambulacral pores are very indis-

tinety indicated; the avenues are sub-parallel, slightly radiating. The anus is exceedingly small in proportion to the size. It is placed at two thirds of the distance from the mouth to the margin. The strengthening buttresses are well developed internally.

The very small anus, its position, and the very minute and comparatively scattered tubercles, easily distinguish this from any of its congeners.

There are some small ovate specimens which appear to belong to a variety of this species.

A large example measures five twelfths of an inch in length by very nearly the same in breadth, and one eighth in height.

It occurs in the Coralline Crag of Ramsholt.

Mr. Morris in his 'Catalogue,' gives the Coralline Crag of Suffolk, as the formation in which *Echinocyamus Suffolciensis* occurs: this species was probably intended.

4. *ECHINOCYAMUS OVIFORMIS*. Plate I, figs. 17 and 18.

The test is ovate, tumid for the genus, remarkably rounded at the sides, and depressed above. Its surface is covered with rather coarse tubercles. The mouth is placed on a plane, or slightly concave ventral surface; it is very large. The vent, though small in comparison, is large in proportion to the dimensions of the test, and is placed on the inferior slope of the terminal tumid margin, a position which at once distinguishes the species from all our other British *Echinocyami*.

This small species, of which I have examined as many as twelve examples, in the cabinet of Mr. Searles Wood, has an immature aspect. Its characters are, however, unmistakeably peculiar. It is from the Coralline Crag of Sutton.

The largest specimen measures two tenths of an inch in length by two twelfths in breadth and one tenth in height.

Genus—*ECHINARACHNIUS*, Van Phelsum.

Discoid, depressed urchins, with open and not converging dorsal ambulacra. Their mouths are small and circular. The vent is small and marginal. They have four genital pores.

One species, if not two, inhabit the North Atlantic now. It is with much doubt that I refer the following fossils to this genus.

1. *ECHINARACHNIUS*? *WOODII*. Plate II, fig. 5 and (same species?) fig. 6.

The fragment of a much depressed, slightly convex ovate urchin, concave underneath, with a sub-central mouth. Represented in Plate II, fig. 8.

Also the small fragment of an ovate, much depressed, slightly convex urchin, with parallel ambulacra, a terminal vent, overhung by a projection of the back, the whole surface covered by close-set, equal, minute tubercles within impressed areolæ, (Plate II, fig. 6,) possibly belonging to a species of *Echinarachnius*.

They are both from the Red Crag. I know no urchins, living or fossil, which can be compared with these curious fragments, of which I would strongly urge collectors to seek for even the smallest portions, in order that some more certain clue to their relations may be discovered. It is not impossible, indeed, that the one represented in fig. 6 may be distinct from that delineated in fig. 8.

They are both from the Red Crag.

Family—SPATANGIDÆ.

These are heart-shaped urchins, more or less elongated and bilateral, having petaloid dorsal ambulacra, a terminal anus, and an excentric mouth, covered by a more or less projecting lip. They have no dental apparatus. The apical disk is perforated by four genital and five ocular holes, but there is the usual number of plates going to its composition. The genera are distinguished from each other by the presence, absence, and arrangement of the fascioles, which are circumscribed bands of minute spines, and by the presence or absence of large tubercles bearing primary spines. No genus of this family has been noticed in strata older than those of the Cretaceous epoch.

Genus—SPATANGUS, *Klein*.

Body depressed, cordate, with heterogeneous ambulacra converging to a genital disk, which is dorsal and entire; superior portion of the lateral ambulacra petaloid. Anterior ambulacrum in a sulcus. Anus terminal; a caudal fasciole, but no dorsal one. Four genital pores. Mouth bilabiate, excentric, placed anteriorly on the ventral surface in front of an escutcheon. Spines slender, curved, the primaries longer than the others, and borne on large tubercles, which are especially developed on the anterior portion of the dorsal surface.

There is no true *Spatangus* known from strata lower than Tertiary. Most of the existing species are natives of the North Atlantic.

1. SPATANGUS PURPUREUS. Plate II, fig. 3.

SPATANGUS PURPUREUS, *Muller*, Zool. Dan. Prod., 2850, and Zool. Dan., tab. vi.

— — *Leske ap. Klein*, p. 238, tab. 43, figs. 3—5; (see, also, *Enc. Meth.*, pl. 157, figs. 1—4.)

- SPATANGUS PURPUREUS, *Lamarck*, Anim. sans Vert., 1st ed., vol. iii, p. 29; 2d ed., vol. iii, p. 324.
- — *Fleming*, Brit. Anim., p. 480.
- — *Blainville*, Man. d'Actin., p. 202, pl. xiv, figs. 1—3.
- — *Forbes*, Brit. Starf., p. 182, (with figure.)
- — *Agassiz and Desor*, Ann. Sc. Nat., 3d ser., vol. viii, p. 6.
- — *Duben and Koren*, Kong. Vet. Akad. Hand., 1844, p. 285.
- ECHINUS PURPUREUS, *Gmelin*, Lin., p. 3197.
- LACUNOSUS, *Pennant*, Brit. Zool., iv, p. 69, pl. 35 and 76.

Identical with this well-known living species, (of which *Spatangus meridionalis* of Risso, and *S. spinosissimus* of Desor, appear to be varieties,) is one of which about half the test is preserved, in the collection of Mr. Searles Wood, from the Coralline Crag of Ramsholt. It differs from our ordinary British form in being slightly more carinate at the sides of the anterior ambulacral sulcus, a character in which it approaches to the more southern varieties, and at the same time agrees with ours in shape and degree of depression; being, indeed, if anything, slightly more depressed. The antero-lateral ambulacra are slightly narrower, the primary tubercles quite as numerous. The specimen is not in such a state as to warrant a more minute description.

2. SPATANGUS REGINA? Plate II, fig. 2.

SPATANGUS REGINA, *Gray*, Ann. Nat. Hist., 2d ser., vol. vii, p. 130?

In the collection of Mr. Brown, of Stanway, there is a large fragment of a true *Spatangus*. It is the greater portion of the upper surface, from the margin of the vent to the anterior extremity, which latter is unfortunately, however, concealed by adhering matter. One of the postero-lateral, and part of one of the antero-lateral ambulacra, are exposed. The postero-lateral ambulacrum is lanceolate, with a gently flexuous outline. The two avenues converge suddenly. There are about 26 pairs of pores in each avenue. Each pair is lodged in a deep and well-defined sulcus. The number of pairs of pores in the antero-lateral ambulacra cannot be made out. The whole of the surface is closely set with miliary granules. On the ambulacral spaces there are no primary tubercles, but in the centre of the postero-lateral and postcal interambulacral spaces, the only ones exposed, there are groups of nearly equal primary tubercles forming curved assemblages. Between them, on the interambulacral spaces, there are curved depressions in the test. The whole body seems to have been broad and depressed. It measured rather more than four inches in length by rather less in breadth.

Another fragment of a true *Spatangus*, also from the Coralline Crag, exhibiting the cordate anterior extremity, the granulated groove of the anterior ambulacrum, tumid and slightly angulated cheeks, and the portion of the anterior surface in front of the mouth, may have belonged to another species, or to only a more tumid form of the same.

Genus—BRISSUS, *Klein*.

Body oval or oblong, tumid; dorsal ambulacra sub-petaloid, circumscribed by a peripetal fasciole; tubercles of dorsal surface all similar; anus terminal, supra-marginal; caudal extremity with a sub-anal fasciole.

The living species of *Brissus* are chiefly tropical. The fossil representatives of the genus are entirely tertiary.

1. BRISSUS SCILLÆ, *Agassiz*. Plate II, fig. 4.

Scilla, De Corp. Mar., pl. iv, figs. 2 and 3.

BRISSUS SCILLÆ, *Agassiz* and *Desor*, Ann. Sc. Nat., 3d ser., tom. viii, p. 13.

SPATANGUS (BRISSUS) PLACENTA, *Philippi* in *Erichson's Archiv.* for 1845, pt. 1, p. 349?

This sea-urchin, one of the largest and most remarkable of all those found fossil in the Crag, varies much in shape, some specimens being oblong, some wide and ovate; the former are usually high, and strongly subcarinated on the back; the latter more depressed, but all have the apex strikingly excentric, and the anterior extremity abruptly truncated. The greatest width of the body is nearly on a line with the terminations of the postero-lateral ambulacra. The tubercles of the back are numerous and closely set, and increase gradually in size in the antean region and towards the apex. The lateral ambulacra are narrow, somewhat linear in shape, and deeply impressed, showing on the surface as four deep radiating furrows, two of which, the antero-lateral ones, stand at right angles to the longitudinal diameter of the shell, whilst the other two, the postero-laterals, are directed obliquely backwards, and form an acute angle at their apical terminations. The latter are a little longer than the former, and contain rather more pairs of pores, the respective numbers in each row being from 27 and 30 to about 30 and 35. The centro-ambulacral space is smooth, or nearly so, in the lateral ambulacra; but in the odd, or antean ambulacrum, which, instead of being impressed and sub-petaloid, is linear and plane, or even slightly elevated, it is regularly and minutely granulated, the large granules or small tubercles forming boundary rows. In the lateral ambulacra, the ridges separating the pairs of pores are minutely granulated. The genital disk, usually obscured in fossil specimens, has four genital holes, the two posterior ones largest, and five eye-perforations, remarkable for their peculiar structure. The peripetal fasciole is very distinctly marked. In front of the antero-lateral ambulacra, it includes a wide somewhat semicircular space, its foremost and central portion crossing the shell at a little below half its height. From this point, tracing its course along each side, it runs with a slight angularity to about two thirds of the distance between the antean and the end of the antero-lateral ambulacrum, before meeting which it makes a single strongly-marked incurved flexure, in this respect

differing from *Brissus carinatus*, the fasciole of which makes two incurved flexures in this region. It then winds closely round the end of the antero-lateral ambulacrum, and ascends rapidly between it and the postero-lateral one, making a deep but wide flexure somewhat truncated at its upper part; it then curves down, following closely the bounds of the postero-lateral ambulacrum, round which it winds and crosses the posterior interambulacral space, with an arched curve not so deeply in-turned as the lateral curves are. The anal extremity of the test is perpendicularly truncated (a character also distinctive between this species and *B. carinatus*), the anus lenticular and large, and placed rather low, the sub-anal or caudal fasciole is broadly subcordate, truncated below. The mouth is transversely semicircular, with a slightly overhanging and prominent lip. The oral ambulacra are subtriangular and radiating. The tubercles of the post-oral spinous space are subequal and radiating.

Length of specimen (presented by E. H. Bunbury, Esq., M.P.) in the Museum of Practical Geology, 4 inches and $\frac{3}{4}$ ths. Breadth, 3 inches. Height, 2 inches and $\frac{1}{2}$ ths.

This remarkable urchin is found in the Coralline Crag. Mr. Searles Wood and Capt. Alexander have taken it, as well as Mr. Bunbury. It varies much in proportion, but is distinctly identical with Scilla's species, which lives in the Mediterranean, and occurs fossil in the miocene of Malta. I purposely omit all references to Lamarck, as there is sad confusion about this *Brissus* and its allies.

Genus—**AMPHIDETUS**, *Agassiz*.

Body cordate, tumid, with heterogeneous ambulacra converging to a genital disk, which is dorsal and entire; superior portion of the lateral ambulacra trumpet-shaped. Anus terminal. A caudal and an intra-petal fasciole, the latter conspicuous on the back, and shield-shaped. Four genital pores. Mouth bilabiate, excentric, and placed anteriorly on the ventral surface, in front of an escutcheon. Spines slender, curved, graduated; no prominent and conspicuous primary tubercles on the dorsal surface.

The living species of this genus are all from the North Atlantic, and its arms. The fossil forms are all from the Upper Tertiaries.

1. AMPHIDETUS CORDATUS. Plate II, fig. 1.

ECHINUS CORDATUS, *Pennant*. Brit. Zool., vol. iv, p. 69, figs. 34 and 75.

SPATANGUS PUSILLUS, *Leske*. Page 230, tab. xxiv, figs. c, d, e, and tab. xxxviii, fig. 5.

— *ARCUARIUS*, *Lamarck*. An. sans Vert., vol. iii, p. 31, and 2d edit., vol. iii, p. 328.

— — *De Blainville*. Man. d'Actin., p. 201.

— *CORDATUS*, *Fleming*. Brit. An., p. 480.

AMPHIDETUS CORDATUS, *Forbes*. Brit. Starf., p. 191.

— — *Agassiz and Desor*. Ann. des Sc. Nat., 3d series, tom. viii,
p. 11.

— — *Duben and Koren*. Kong. Vet. Akad. Handl., 1844, p. 285.

Body broadly cordate, elevated posteriorly, depressed, and declining anteriorly; sub-angulated at junction of sides and base. All the lateral ambulacra exterior to the ovate coffin-shaped fasciole, the two rows of pairs of pores composing each converging gradually towards their outer terminations. Plates of dorsal surface closely set with minute tubercles, occupying squamated areolæ. On the under surface they are larger, and not so closely packed. Anal extremity steep and high: the vent in a slight depression, in its upper part semi-circled by a fasciole, which is incomplete above; a sub-cordate caudal fasciole below it. Post-oral spinous space broadly lanceolate. Oral ambulacra occupying smooth avenues. Spines fine, curved, slender, fragile, sub-spathulate, well preserved on the specimen described. Length, $1\frac{9}{12}$ ths of an inch; breadth, $1\frac{7}{12}$ ths; height at caudal extremity, 1 inch.

In the Coralline Crag.

ORDER.—ASTERIADÆ.

The true star-fishes have lobed bodies, more or less depressed, and prolonged into radiating arms, more seldom reduced to a pentangular disk. The whole of the upper surface is covered by a coriaceous skin, studded with a reticulation of calcareous plates, and often bearing superficial spines, tubercles, and pedicellariæ. There is always a madreporiform tubercle present; and generally a vent. In the centre of the ventral surface is the mouth, whence radiate to the extremity of the rays or arms as many ambulacra as there are lobes. In these, the suckers are lodged, ranged in ranks of twos or fours, bordered by peculiar and often spinigerous plates. The only well-defined fragment of a Crag star-fish is a member of the Family URASTERIÆ, in which there are always present four rows of suckers in each ambulacral groove.

URASTER, *Agassiz*.

Body deeply lobed, or produced into five (rarely more) slender arms, spinose above. Margins not bordered by conspicuous plates. Suckers four-ranked.

1. URASTER RUBENS. Plate II, fig. 7, *a* and *b*.

ASTERIAS RUBENS, *Retz*. Vetensk. Acad. Handl., vol. iv, p. 236.

— — *Linnaeus*. S. N., 1099.

- ASTERIAS RUBENS, *Muller*. Zool. Dan. Prod., p. 2830.
 — — *Lamarck*. An. sans Vert., 1st ed., vol. ii, p. 512; 2d ed., vol. iii, p. 160.
 — — *Blainville*. Man. d'Actin., p. 239, pl. xxii, A, B.
 — GLACIALIS, *Pennant*. Brit. Zool., vol. iv, p. 60, No. 54.
 — — *Fleming*. Brit. An., p. 487.
 STELLONIA RUBENS, *Agassiz*. Prod.
 — — *Forbes*. Wern. Mem., vol. viii, p. 121.
 URASTER RUBENS, *Forbes*. Brit. Starf., p. 83, (with figure.)
 ASTERACANTHION RUBENS, *Muller and Troschel*. Syst. der Asteriden, p. 17.

To the commonest of our native star-fishes, I refer a very remarkable and rare fragment from the Red Crag, in the possession of Miss Alexander, who kindly communicated it for description and representation.

It consists of a number of ambulacral and other ossicula of an arm of a *Uraster*, in very perfect preservation. The ambulacral bones are linear, geniculated at their inner extremities, and combined to form a ridge. From their outer terminations spring some of the confluent chains of ossicles, that went to the strengthening of the superior arched integument of the arms.

The specimen is represented in fig. 7, *a*, of the natural size. Ossicula, probably derived from the same, or a closely allied star-fish, have been found by Mr. Searles Wood. For a description of the *Asterias rubens*, the reader may consult the 'History of British Star-fishes.'

ORDER.—CRINOIDEA.

The feather-stars and lily-stars, as the members of this order are popularly styled, differ from all other Echinodermata, in having their reproductive organs attached to the pinnacles of radiating jointed arms. Their viscera are included within a cup of calcareous plates, which, either in the younger stages of growth or throughout life, as appears to have been the case with most of the fossil species, was borne on the summit of a jointed columnar stem.

The few remains of *Crinoids* found in the Crag belong to the Genus *Comatula*, one of those types of which the adults are free.

The buccal orifice is in the centre of the visceral disk; the vent at the extremity of a tube proceeding from it.

COMATULA, *Lamarck*.

Cup simple, of a single piece, bearing five bifurcating pinnated arms above, and a number of chelate jointed filaments attached to its under surface, except in the centre, where there is a disk to which, in its early stage, the extremity of a column was attached.

Although the remains of *Comatulæ* found in the Crag are exceedingly fragmentary, and consist only of minute and much injured cups, they are sufficiently well marked to enable us to pronounce with certainty on their affinities, and also to speak with confidence as to their distinctness from any described forms. They have, curiously enough, relations more near to Indo-Pacific types than to any found now in the Atlantic and its arms.

At the present time, two species of this genus inhabit the British Seas.

1. COMATULA WOODWARDI. Plate I, fig. 20.

Three little cups, each of which measures rather less than three millimetres across by about one in height, contained in the collection of Mr. Searles Wood, and discovered by that naturalist in the Coralline Crag of Sutton, have belonged to a species of *Comatula*.

They are deeply and widely excavated above, the breadth of the excavation occupying more than a third of the total width, so as to give a narrow aspect to the superior border of the cup. This margin is broken up by rather broad radiating furrows. The under surface is convex; centrally, it is smooth or minutely punctated, and plane; at the sides, it is sloping, swollen, and pitted by two closely set circles of impressed and rather large sockets for filaments, ten in each circle.

2. COMATULA BROWNII. Plate I, fig. 19.

I have given this name, in honour of Mr. John Brown, of Stanway, to the cup of a very distinct *Crinoid* from the Coralline Crag, of which two specimens have been communicated from Sutton by Mr. Searles Wood.

The largest measures two twelfths of an inch in diameter by two millimetres in height. The excavation in the centre of the cup, superiorly, is rather more than a millimetre in diameter, and one half the breadth of the distance between it and the flattened marginal portion. The under-side exhibits but slight traces of the central disk, the alternating circles of tentacular scars occupy the remainder of its slightly convex surface.

3. *COMATULA RANSOMI*. (*See Woodcut below.*)

A number of cups of a third species of *Comatula* have been found by Mr. Searles Wood, in the Coralline Crag of Sutton. It probably bore a nearer resemblance to our existing British forms of this genus than any of its fossil allies.

The largest of these disks measures one twelfth of an inch in diameter by rather more than one millimetre in height. The excavation occupies more than a half of the total width, rendering the marginal sulcated portion very narrow. The under surface is conic and reversely cup-shaped, depressed at the base, and marked by the sockets of numerous feelers, which were ranged in about three rows on the sides, the largest circle of about fifteen pits.



ECHINODERMS OF THE LONDON CLAY.

SUB-KINGDOM. — RADIATA.

CLASS.—ECHINODERMATA.

Family.—CIDARITIDÆ.

THE members of this family are distinguished among those which have the vent and mouth at opposite poles, and the former aperture surrounded by the genital and ocular plates, by the pairs of pores in their avenues being ranged in true single file, and by their narrow ambulacra, upon which are no primary spines. They have a well-developed dental apparatus. Of all the families of *Echinidea* this is the most ancient, certain palæozoic sea-urchins appearing to be truly species of *Cidaris*.

Genus—CIDARIS, *Lamarck*.

Test turban-shaped, thick, the ambulacral areas very narrow, and bearing secondary tubercles and spines only; its interambulacral segments broad, ornamented with large and few perforated tubercles, placed on smooth or crenulated bosses, and bearing variously shaped strong spines, always different in form and sculpture from the secondary spines. Pores of the avenues in strict single file. Oral membrane covered with imbricated scales. Eye-plates and genital plates all perforated.

The existing species of *Cidaris* are distributed through the seas of all regions, but the majority are congregated within the tropics. The number of mesozoic species was much more considerable. Of tertiary forms our knowledge is not very precise; and unfortunately, as in the instance about to be noticed, confined to their spines only in too many cases.

1. *CIDARIS WEBSTERIANA*. Plate III, fig. 4.

I have given this name to the spines of a *Cidaris* collected by Mr. Edwards at Barton, the only relic of the genus as yet noticed in British tertiaries. Their shape is stout and cylindrical, slightly swelling out at their halves, ornamented by about twelve longitudinal rows of rounded and nearly equal tubercles, the grooves between being very narrow and very minutely striated. Between the collar of the spine and the commencement of the ridges of tubercles, is a shallow well-defined nearly smooth neck. The collar is not crenulated; from within it projects the nipple-like deeply hollowed articular surface. A large example measures $\frac{1}{4}$ th of an inch in length by $\frac{1}{16}$ th in diameter at its most tumid part.

In the Museum of Practical Geology; presented by F. E. Edwards, Esq.

Family.—ECHINIDÆ.

Genus—ECHINUS, *Linnaeus*.

(See page 2.)

1. *ECHINUS DIXONIANUS*. Plate III, fig. 3.

As yet no body, or even plate, of any true *Echinus* has been found in British Eocene strata. A single spine belonging to this genus has, however, been procured by Mr. Edwards at Barton. It evidently formed part of the armature of a large sea-urchin. It is ornamented with about twenty-four depressed, rather narrow longitudinal ribs, separated from each other by very fine grooves, and at their lower parts as if doubled, owing to the presence of a finer groove down the centre of each rib. The collar of the spine is raised, tumid, and crossed by the grooves. The neck is pyramidal and truncated, with a rather small articular surface. The spine itself is imperfect; but when entire, may have measured three quarters of an inch in length by one eighth in breadth at the collar.

Genus—ECHINOPSIS, *Agassiz*.

Body spheroidal, inflated, with homogeneous ambulacra converging above to a genital disk, composed of five perforated genital plates alternating with five perforated oculars, and forming a ring around an apical vent. Mouth central and inferior. Tubercles perforated, as in *Diadema*, but borne upon plain and not crenulated bosses.

This genus is intermediate between *Echinus* and *Diadema*. The known species are all fossil, and either from the upper part of the Cretaceous strata, or from Eocene beds.

1. *ECHINOPSIS EDWARDSI*. Plate III, fig. 2.

One of the most interesting of the Echinoderms from British Eocene strata is this, obtained by Mr. Edwards at Brackelsham, and also in the uppermost marine beds at Barton. Two specimens have been found, one showing the upper surface and plates in great perfection, and the other much less perfect, displaying, nevertheless, the general shape, although much crushed. The interambulacral spaces are to the ambulacra as 3 to 1. Each interambulacral row of plates is composed of about twelve in longitudinal series. Each plate bears a single perforated primary tubercle on the summit of a gently prominent smooth boss. On its inner side is a rather prominent secondary tubercle, and about its base a somewhat irregular circle of granules. The general arrangement of the primary tubercles on the interambulacral spaces is such as to make them appear as two close rows set rather widely apart, thereby contrasting with the closely placed rows of primaries in the ambulacral segments, where, in like manner, there is a single tubercle on each plate. The avenues are broad in consequence of the very oblique transverse series of pairs of pores, falling regularly into ranks of threes, an arrangement noticed as occurring in this genus only in the *Echinopsis Gacheti* of Desmoulins, from the tertiary of Blaye, a large species as yet undescribed and unfigured. The disk of our *Echinopsis* is destroyed and the mouth obscured. Associated with it are very slender spines, squamose, with circles of appressed spinules, and in one instance spatulate at the tip. These, judging from their analogy with the spines of the allied genus *Astropyga*, probably belonged to our urchin.

Echinopsis Edwardsi measures half an inch in breadth by three tenths of an inch in height.

Genus—CÆLOPLEURUS, Agassiz.

Body a depressed spheroid, of five ambulacral and five interambulacral segments, all spinigerous, below and laterally, but becoming naked towards their summits, where they converge to a disk of five perforated genital, and as many perforated very large ocular plates, forming a ring around an apical vent. Tubercles imperforate and bosses simple. Mouth very large. Pores disposed in single file throughout.

The species of this genus, enumerated by Agassiz, are all Eocene fossils, and are remarkable for singularity and beauty. Unfortunately our only English one is found in the condition of pyritous casts, mostly in the London clay of Sheppey, and presents but very imperfect indications of the peculiarities of its organisation.

1. *CÆLOPLEURUS WETHERELLI*. Plate III, fig. 1.

ACHROSALENIA, species of, *Morris*. Cat., p. 47.

Depressed, orbicular, convex above, plain below, with somewhat compressed sides. Ambulacral areas very narrow, smooth above, ornamented at their inferior portions by a few large alternating tubercles. Interambulacral spaces also quite naked above, and similar, bearing few large alternating tubercles in their lower portions. The tubercles of lower parts of the segments occupy the whole of the base around the very large mouth. The avenues are broad, though composed of pores ranged in single file, this arrangement becoming obscure near the mouth. The apical disk is remarkable for the very large ocular plates. In consequence of the bad condition of the tests, both tubercles and pores are often obliterated. In Mr. Wetherell's collection, is a specimen apparently of this species from Highgate Archway, with the spines imperfectly preserved. They were long, slender, and longitudinally grooved, the ridges few and granulated.

Most of the numerous examples of this urchin have been procured in Sheppey by Mr. Bowerbank. The largest example measures half an inch in diameter by a quarter of an inch in height.

Family.—SPATANGIDÆ.

(See page 13.)

Genus—HEMIASTER, *Desor*.

Inflated urchins with heterogeneous ambulacra, distinctly petaloid in their dorsal portions, and often lodged in depressed spaces. They have terminal vents and excentric bilabiate mouths. The petals of the back are circumscribed by a slightly undulated fasciole. There is no sub-anal or intrapetal fasciole. There are no large primary tubercles mingled with the very uniform secondaries that cover the plates. All the known species are from Cretaceous or Eocene strata. They are very similar to each other in general aspect, so that it is requisite to have recourse to critical distinctions in defining the species.

1. *HEMIASTER BOWERBANKII*. Plate III, fig. 6.

This little urchin is very tumid, much elevated posteriorly, declining anteriorly. Its highest portion is just above the truncated anal extremity. The contour is obcordate, with an obscure tendency to a hexagonal outline. The dorsal ambulacra are widely petaloid, very unequal, and all lodged in deep excavations. The antero-lateral ones are twice as long as the postero-laterals. The latter are broadly ovate, and have about eight pairs

of pores in each row. The antero-laterals are oblong-ovate, and have about twelve pairs of pores in each row. The hollowed-out portion of the odd ambulacrum is ovato-lanceolate, and longer than the antero-laterals by a third. The elevated spaces between the petals are narrow, and as if pinched up. The sides are very prominent. The caudal extremity is perpendicularly truncate. The vent is small, and placed very high up. The ventral surface is nearly plane, with rounded sides. The mouth is transversely oval, and scarcely bilabiate.

A large example measures half an inch in length by the same breadth, and four tenths of an inch in height. As the test is not preserved in any specimen that I have seen, I have not been able to make out the details of the plates, tubercles, and fasciole.

Mr. Bowerbank has found many specimens in the London Clay of Sheppey.

2. HEMIASTER? PRESTWICHII. Plate III, fig. 5, *a*, *b*, *c*.

Resembling the last in general aspect, but growing to a much larger size, and differing in important particulars. It is very tumid, and suborbicular or slightly pentagonal in outline. The postero-lateral interambulacral space is most elevated, and the back gradually declines towards the frontal extremity. The ambulacra are subpetaloid, and almost at the surface of the test, the odd one only being lodged in a shallow depression. The antero-lateral petals are two and a half times as long as the postero-laterals. The latter are narrowly oblong, and in a moderate sized example present six pairs of pores in each row. The antero-laterals are narrowly lanceolate or subparallel, and composed of about twelve pairs of pores in a row. The caudal extremity is obtuse, and in its middle portion perpendicularly truncate. The ventral surface is somewhat convex. The mouth is small. The plates that are preserved are covered with slightly scattered small equal tubercles, the interspaces being granulated. I cannot detect any traces of fascioles, and am strongly inclined to believe that this urchin is really a species of *Macropneustes*, but, until better specimens are found, do not like to venture on the introduction of that characteristically Eocene genus into the British lists.

Most of the specimens of this curious sea-urchin are deprived of all traces of their tests. They have been found in the London Clay proper, especially at Sheppey, by Mr. Bowerbank. The dimensions of a perfect, though not one of the largest examples, are as follows :

Length, $0\frac{6}{10}$ ths of an inch. Breadth the same. Height very nearly the same.

3. HEMIASTER BRANDERIANUS. Plate III, fig. 8.

The remains of this rather large species are much compressed and broken down, so that it is difficult to determine its original form. It appears to have been broadly obcordate and elevated, though not over much posteriorly. It attains to three times the

dimensions of the *H. Bowerbankii*. The dorsal ambulacra are conspicuously petaloid, and all lodged in shallow depressions. The antero-laterals are rather less than twice as long as the postero-laterals. The latter are ovate, with truncate extremities, and have from twenty to twenty-four pairs of pores in each row. The antero-laterals have about thirty pairs in a row. These numbers refer to full-grown examples. Younger ones have fewer pores. The plates are covered by squamose elevations, bearing nearly uniform tubercular bosses. The peripetal fasciole is rather broad, and but very slightly undulated. The odd ambulacrum is studded with minute granules.

I have not seen the under side of this species; nor, though the test is partially well preserved in two instances, is the anal extremity in such a state as to enable me to say with certainty whether there may not be a caudal fasciole. In such case the species must be referred to *Brissus*.

There are two varieties, which may eventually prove to be distinct species. The one is from Barton (Mr. Bowerbank), and the other from Haverstock Hill (Mr. Edwards). The former is represented in Plate III, figs. 8, *a*, *b*, and *c*, and the latter in fig. 8, *d*.

Genus—EUPATAGUS, *Agassiz*.

More or less ovate and sub-depressed urchins, often of considerable dimensions, with heterogeneous ambulacra distinctly petaloid or subpetaloid in their dorsal portions. The odd ambulacrum is lodged in a more or less deep furrow. The dorsal petals are circumscribed by a distinct fasciole, and there is another well-marked sub-anal or caudal fasciole. The dorsal plates within the peripetal fasciole bear, besides the ordinary tubercles, large primary ones, in the manner of *Spatangus*. The mouth is excentric and bilabiate, the vent terminal.

The species of this genus at present known are either living, or from Eocene strata. The existing forms inhabit the Australian seas. No fossil belonging to it has hitherto been observed in Britain.

1. EUPATAGUS HASTINGLE. Plate III, fig. 7.

The body of this remarkable and elegant sea-urchin is regularly ovate, and, though much compressed in the specimens, must have been gently convex. The ambulacra are petaloid, with long petals of lanceolate shape, and of equal lengths. Of the lateral ambulacra the two anterior stand nearly at right angles to the axis of the test, the two posterior form an acute angle. The odd one is nearly parallel-sided. None of them are lodged in sulci, but all at the surface of the test. There are about twenty-four pairs of pores in each row on the lateral petals. The petals are circumscribed by a narrow, very distinct fasciole, not sinuated at the sides. The plates are covered with scattered granules

and secondary tubercles. Within the fasciole the interambulacral spaces bear conspicuous primary tubercles, scattered. These are very small, perforated, and placed on elevated bosses surrounded by a broad excavated areola. Beneath, in the neighbourhood of and behind the mouth, the primaries are more numerous, and regularly arranged. The caudal fasciole is distinctly seen.

The length of a specimen in the Museum of Practical Geology is one inch and six tenths, by rather more than an inch and a quarter in breadth.

This fine addition to our British lists was discovered in the clays at Barton, during the researches of the Geological Survey. I have dedicated it to the Marchioness of Hastings, whose indefatigable researches among the Tertiaries of the cliffs at Hordwell and Barton have contributed greatly to our knowledge of the organic remains of Eocene strata in Great Britain.

I have compared this species with excellent examples of Biaritz *Eupatagi*, kindly communicated by Mr. Pratt; from all of them, however, it differs essentially.

Genus SCHIZASTER, Agassiz.

Body cordate, depressed, broad; apical disc placed far back; ambulacra lodged in very deep depressions, unequal, surrounded by a peripetal fasciole, from which a lateral supplementary fasciole proceeds on each side towards the anus, and passes beneath it.

1. SCHIZASTER D'URBANI. (*See Woodcut at the end of this Memoir.*)

Mr. D'Urban has communicated a sea urchin from the Barton beds in Alum Bay, apparently belonging to this genus, but retaining so few fragments of the test that it is impossible to pronounce upon its true position with certainty.

Its outline was broadly cordate. As in many *Schizasters*, the postero-lateral ambulacra are short compared with the antero-laterals. The former are oblong and contain about eighteen pairs of pores in each series. The latter are broadly lanceolate and arcuated, and have about twenty-seven pairs of pores, lodged in rather broad transverse grooves in each series. Both antero- and postero-laterals are placed in deep depressions of the test. Between the former and the odd or anterior ambulacrum, the test is swollen and pinched, as is usual in this genus. The odd ambulacrum is long and broad, seated in a deep steep-sided, flat-based sulcus. The other characters of the species are not sufficiently clear for description. Fragments of two other specimens occur in the same slab with that here described. It was brought to me too late for being included in the plate, and has consequently been figured in a vignette at the close of this memoir.

Genus—SPATANGUS, *Klein*.

(See page 13.)

1. SPATANGUS OMALII. Plate III, fig. 9.

SPATANGUS OMALII, *Galeotti*, Mém. sur le Const. Geol. de la Province de Brabant, p. 191, pl., supp., fig. 1.

Mr. Edwards has found at Barton fragments of a true *Spatangus*. These, on comparison with an authentic example of the *Spatangus Omalii* of Galeotti, brought by Sir Charles Lyell from Eocene strata in Belgium, prove to be, almost beyond a doubt, identical with that species. I have figured the fragments with a restoration founded on the Belgian *Spatangus*.

The body was rather broadly cordate, and depressed above. The fragments preserved show that the elevation of the dorsal surface was moderately uniform, and that the margins were rather compressed. The dorso-lateral petals were lanceolate, with truncate extremities. They were placed quite at the surface of the test, and their pores were connected by grooves. The surface of the plates appears as if punctated and minutely granulated. Within the anterior and lateral interambulacral spaces, are a few scattered large and deep areolæ surrounding elevated bosses, bearing the primary tubercles. These were absent from the hinder extremity of the test. The ventral surface was plane, or slightly concave, and bore numerous large primary tubercles with thin areolæ. The mouth and vent are not preserved.

The best preserved fragment indicates a length of six tenths of an inch, and a breadth of rather less dimensions.

ORDER.—ASTERIDEA.

(See page 17.)

Family.—ASTERLE.

The star-fishes of this group have regularly depressed flattened bodies, their upper surfaces covered with paxillæ or coronated spines, and their margins bordered by a regular double series of plates. They have no anal pore.

Genus—ASTROPECTEN, *Linck*.

Body stellate, few (five) rayed; rays flat on both sides, regular; surface of the skin dorsally, and upper surfaces of the rays covered with paxillæ. No vent. Ambulacra bordered by spines, and furnished with two rows of suckers. Margins of the rays bordered by a double row of conspicuous plates.

1. *ASTROPECTEN CRISPATUS*. Plate IV, fig. 2.

ASTERIAS, sp., *Ansted*, *Geology*, vol. ii, p. 66, woodcut.

ASTROPECTEN CRISPATUS, *Forbes*, *Mem. Geol. Surv. Great Britain*, vol. ii, pt. 2, p. 479:
and *Fig. and Desc. of Brit. Org. Rem.*, dec. i, pl. 3, fig. 3.

This is the commonest of Eocene star-fishes, and specimens from the London Clay of Sheppey are preserved in many cabinets. It has long attracted notice, but was first figured, without a specific name, by Professor Ansted. It seems to have been of a firmer and less brittle habit than its brethren, since it is the only one of our London Clay species that presents anything near completeness of shape.

It has five triangularly lanceolate rays radiating from a broad central disk. The pyritous condition in which the examples are always found, prevent our making clearly out the details of its ornamentation, but apparently the dorsal surface was studded with rather large paxillæ. The margins of the arms are bordered by very numerous, narrow, closely-set oblong plates, varying from 25 to above 35 on each side of the arms of the larger specimens examined. These gently decline outwardly, where they meet with similar under-plates, so that the edges of the arms seem as if somewhat compressed. All the marginal plates bear at their outer and upper edges short obtuse lanceolate spines. There are indications of ossicula of considerable size, and probably spinigerous, bordering the narrow avenues. The greatest diameter, from tip to tip of rays, in one of the most perfect specimens which I have seen (in the cabinet of Mr. Bowerbank), is two inches and a quarter. The breadth of the disk in this example is one inch. The species grew to a larger size.

2. *ASTROPECTEN ARMATUS*. Plate IV, fig. 1.

ASTROPECTEN ARMATUS, *Forbes*, *Mem. Geol. Surv. Great Britain*, vol. ii, pt. 2, p. 479;
and *Fig. and Desc. of Brit. Org. Rem.*, decade i, pl. 3,
fig. 4.

The specimen originally described and figured of this species is still the only one known. It is the greater part of the under surface of a single arm. The marginal ossicula bear narrow elevated ridges, upon which are impressions indicating the sockets of spines. On their outer sides are long, slender spines, perfectly preserved. Indications may be perceived of fasciuli of short spines, in threes or fours, on the ossicles bordering the edges of the avenues. It is very distinct from any other Eocene star-fish as yet observed. The fragment measures nine twelfths of an inch in breadth at its base, and one inch three twelfths in length. The spines and plates are respectively about three twelfths of an inch in length. It was procured in the Clay of Sheppey.

3. *ASTROPECTEN* ? *COLEI*. Plate IV, fig. 3.

Among some fragments of fossil star-fishes obtained by the Earl of Enniskillen in the London Clay of Sheppey, and now in the Museum of Practical Geology, is one belonging to a very distinct type from any described, but unfortunately too imperfect to afford certain indications of its generic affinities. I have placed it provisionally under *Astropecten*. It may, however, be a *Luidia*.

It consists of portions of two, if not four rays, evidently originally, as the parallelism of their sides indicates, of very considerable length. Their margins are bordered by two series of narrow plates, each bearing an elevated crest or ridge, with very steep sides. These ridges bear traces of pits for the attachment of spines. Those of the inferior plates are gently curved, and become broader and flatter towards the avenues. Within them, towards the avenues, are broader polygonal plates, with strongly marked spine-sockets. The spines that lie about are stout at their bases, and taper gradually to an obtuse extremity. Complicated arrangements of small spines bordered the avenues. The diameter of one of these arm fragments is eight twelfths, and the thickness five twelfths of an inch.

Genus—*GONIASTER*, *Agassiz*.

The star-fishes of this genus have pentagonal bodies covered by tessellated ossicula, which are usually ornamented with numerous granules, and sometimes spines. They have a central mouth in the midst of the five radiating avenues below, and an excentric vent on their dorsal disk. They are all of a depressed form, and their ray and body-margins are bordered by two series of large plates, forming their edges. The suckers in their avenues are ranged in two rows.

1. *GONIASTER STOKESII*. Plate IV, fig. 6.

GONIASTER STOKESII, *Forbes*. Mem. Geol. Survey of Great Britain, vol. ii, pt. 2, p. 475.
Fig. and Descr. of Brit. Org. Rem., dec. i, pl. 3, fig. 1.

Next to the *Astropecten crispatus*, this is the commonest of the species of star-fishes of which remains occur in the London Clay of Sheppey. It has never, however, been found in a perfect condition, and it is just possible that more than one species may be confounded under the name.

The general form appears to have been that of a pentagon, with greatly produced and slender angles. The upper surface was covered by unequal polygonal ossicles, all punctated for the insertion of minute granules. The edges of the body and rays were bounded by a double series of cuboidal, stout, steep-sided marginal plates, with very obtuse and gibbous, but not spiniferous or truly tuberculated angles. The surfaces of

these plates are pitted all over, indicating that they were covered by minute polygonal granules. The marginal plates were exceedingly numerous, and towards the extremities of the rays became so approximated, that the rows of each side of an arm nearly or quite touched. The under-surface was covered by large punctated flat polygonal ossicles closely set, and along the margins of the avenues are stouter and more convex ones that bore short spines and were grooved. Towards the slender extremities of the arms these occupy all the space between the marginal plates.

Fine fragments of this star-fish are preserved in the Museum of Practical Geology, to which they were presented by Mr. Charles Stokes, and in the cabinet of Mr. Bowerbank.

2. GONIASTER MARGINATUS. Plate IV, fig. 4.

GONIASTER MARGINATUS, *Forbes*. Mem. Geol. Surv. Great Britain, vol. ii, pt. 2, p. 475 ;
and Fig. and Descr. of Brit. Org. Remains, dec. i, pl. iii, fig. 2.

The only known fragment of this star-fish is the one described in the first decade of 'British Organic Remains,' and procured by Mr. Charles Stokes from the London Clay of Sheppey.

It consists of five superior, and as many inferior marginal plates. The upper ones are large, oblong, regularly declining on their outer sides, and of comparatively little altitude. Their surface is but slightly convex, thickly punctured all over, and bordered laterally by a distinct elevated rim. The inferior plates are similar, but have even more elevated margins, and the rim is continued on them across their outer sides. The dermal ossicles are small and punctate. The length of the fragment is three eighths, and its breadth less than two eighths of an inch.

3. GONIASTER TUBERCULATUS. Plate IV, fig. 5.

In the Museum of Practical Geology there is a fine fragment of a ray, which, whilst it resembles in many particulars *Goniaster Stokesii*, exhibits characters that entitle it to be regarded as a portion of a distinct species. The part preserved measures one inch and four tenths in length, by one inch three tenths in breadth at its base, and seven tenths of an inch towards its extremity. The dorsal surface appears to be covered by small irregular ossicula. The margin is flanked by two series of nearly equal cuboidal plates, with steep sides, and slightly rounded summits; these are remarkable for bearing a large areolated tubercle, one on each, at their obtuse external edges. These tubercles are larger on the upper than on the under plates. The whole surface of each plate, except the tubercle, is closely pitted, and on some are preserved the small closely-set polygonal granules that occupied the pits. The dermal ossicles of the ventral disk are rather large. The avenues are bordered by strong square plates, bearing short, obtuse, stout spines.

The specimen was procured by the Earl of Enniskillen from the London Clay of Sheppey. I have seen other fragments of the same species.

ORDER.—OPHIURIDEA.

The Brittle-stars have orbicular or pentagonal bodies, covered above with a skin, which is either naked, squamose, or spinous. Below they have a central mouth, from which five long, simple, flexible arms, protected by plates and spines, radiate far beyond the disk. At the base of each ray there are two brachial plates studding the dorsal surface; they have no vent. The genital pores open below. Their arms are furnished with cirri.

OPHIURA, *Lamarck*.

In the Brittle-stars of this genus the dorsal surface of the body is covered with smooth scales or plates. The interbrachial shields at the bases of the arms are conspicuous, and there is a fringe of minute spinules on the margins of the small plates above them immediately appressed on the arm-bases; these latter are inserted into the disk. The inferior intermediate plates are hollowed out at their sides, and of conspicuous dimensions. The mouth is bordered by projecting ossicles, edged by a single row of minute obtuse papillæ. The side plates of the rays bear appressed spines.

1. OPHIURA WETHERELLI. Plate IV, fig. 7.

OPHIURA, sp. *Wetherell*, Geol. Proc., i, p. 417.

— *Morris*, Cat. Br. Fos., p. 55.

Some years ago Mr. Wetherell put on record an Eocene *Ophiura* from near Hampstead, and has since found at Highgate, in concretionary masses, numbers of small *Ophiuræ* all of one species. They have orbicular bodies covered above by rather large plates, arranged more or less concentrically, and by large triangular, sub-parallel, brachial shields. Traces of the small clasping scales bearing a comb of spinules, may be seen in one example. The under side exhibits clear traces of the peculiar arrangements of the genus to which it belongs. The arms are about three times as long as the diameter of the disk, and are gently tapering. The central scales of their upper surfaces change rapidly from broadly quadrangular to a sub-triangular shape, and eventually become partially overlapped by the large lateral scales; each of the latter bears four or five tapering, rather short spines. On the under side of the ray the lateral scales meet and join nearly to their extremities, where a small triangular central scale is interposed.

The breadth of a disk is three-twelfths of an inch.

I cannot find sufficient distinctions between this and some well-preserved fragments of an *Ophiura*, discovered by the Marchioness of Hastings in the High Cliff at Barton, to warrant the considering of the latter, at present at least, as a distinct species.

ORDER.—CRINOIDEA.

(See page 18.)

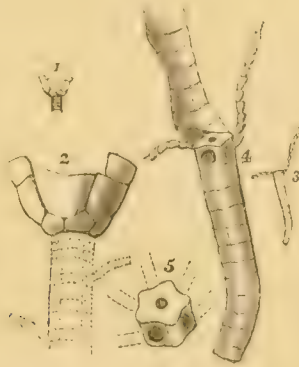
Genus—CAINOCRINUS, *Forbes*.

(From *καίρος*, new, and *κρίνον*, a lily.)

Cup basin-shaped, constituted of a pelvis formed out of five free plates, alternating with five large ascending radials. Column obscurely pentagonal, furnished with articulated ramules, arranged in distant whorls. Joints with stellated articular surfaces.

I have instituted this genus for the reception of a very remarkable Crinoidal body, in the collection of Mr. Bowerbank. The proportions and shape of the cup are such, that at first glance it has more the aspect of a Palaeozoic than of a Tertiary Crinoid. It bears also considerable resemblance to some of the less normal forms of *Millericrinus*. It is however, a member of the same group with the *Pentacrinus*. I should not be at all surprised, if some of the columns described here under the name of *Pentacrinus* were eventually to turn out portions of *Cainocrini*.

1. CAINOCRINUS TINTINNABULUM.



[Fig. 1. Nat. size.—2. The cup and upper joints of column magnified.—3. Portion of a column of the natural size.
4. The same magnified.—5. A joint, with the sockets for the ramules.]

Of this curious Echinoderm, the greater part of the cup with a portion of the column attached, are preserved in the collection of Mr. Bowerbank, who procured them from the London Clay, at Hornsey. Mr. Wetherell has two fragments of columns, found near Copenhagen House, which appear to belong to the same species.

The cup measures $\frac{1}{12}$ th of an inch in height by two tenths in diameter. The column attached is rather less than one twelfth of an inch in diameter. The cup is formed of five rather large and gradually ascending pelvic plates, crowning a slender column, which does

not thicken or swell out at the point of junction. The five plates of the pelvis alternate with five large, slightly convex, ascending primary radials, which bear the first arm-plates large also, but of only half the height. All the plates are smooth. The arms, &c., are destroyed. The column is uncompressed, very equal in its proportions, very smooth, with slightly undulating joints, whose sutures appear slightly curved externally, and whose articular surfaces are roughly radiated. The perforation is very small. The whorls of ramules are very distant; their sockets are large and deeply impressed. They are slender, but strongly jointed.

Genus—PENTACRINUS, *Miller*.

Cup very shallow, constituted of a pelvis composed of a single piece formed out of five anchylosed plates, alternating with five primary radials. Column more or less distinctly pentagonal; furnished with articulated ramules. Joints with stellated articular surfaces.

I. PENTACRINUS SUBBASALTIFORMIS. Plate IV, figs. 8, 9, 10.

PENTACRINUS SUBBASALTIFORMIS, *Miller*. Nat. Hist. of Crinoidea, p. 140.

— — — *Wetherell*. Trans. Geol. Soc., London, 2d series, vol. v, pt. 1, p. 136, pl. viii, fig. 4.

— — — *Austen*. Monog. Rec. and Fos. Crinoidea, p. 122, pl. xvi, fig. 2.

— DIDACTYLUS, *Auide D'Orbigny*. Mém. Soc. Géol. France, 2^{de} ser. vol. ii, pl. v, fig. 18?

Miller, in his famous work upon *Crinoidea*, proposes the name of *Pentacrinites subbasaltiformis* for the columns of a Crinoid, found by Mr. James Sowerby in the London Clay at White Conduit House, Islington, and mentions that similar columns occur at Richmond and at Kensington. He remarks that "these columns much resemble in size and shape those of *Pentacrinites basaltiformis*, but have the angles more rounded. From their exhibiting no marks of muscular corrugation at their exterior surface, and the joints being of uniform thickness, I apprehend the fragments before me to be full grown columnar portions." It was figured by Mr. Wetherell in the illustrations to his paper entitled "Observations on a Well dug at Hampstead Heath," and since by Mr. Austin, in his "Monograph of Recent and Fossil Crinoidæa."

Numerous fragments of stems have been found. These vary from round to very obtusely pentangular, and from five lined to five grooved along this length. The joints are of equal dimensions, and are plane and quite smooth externally. The articular surfaces present rounded crenated lobes. At intervals, ramules are given off opposite, or very nearly opposite, each other, disturbing the symmetry of the joints from which they spring. In the example represented, Plate IV, fig. 8, the diameter of the joints is one fourth of an inch, and their altitude one tenth of an inch.

In Mr. Wetherell's collection are several fragments of the arms and pinnules, but none in a condition sufficiently good to enable us to make out the details of the head. The arm-joints were rather strong, and equal, rounded dorsally, and smooth. The pinnules were tapering, and about seven times as long as the arms are broad.

This species has been found abundantly in several localities of the London Clay; as at Hampstead, Hornsey, Copenhagen Fields, Chalk Farm, Sheppey, and Herne Bay. The fragments of stems vary much in degree of rotundity and indications of lobation. Young examples are more distinctly five-lobed than old specimens.

2. PENTACRINUS SOWERBII. (*See Woodcut*, p. 36.)

PENTACRINUS SOWERBII, *Wetherell*. Trans. Geol. Soc., London, 2d series, vol. 7, p. 132, pl. viii, fig. 4.

— — *Austen*. Monog. of Recent and Fossil Crinoidea, p. 123, pl. xvi, fig. 3, *a* and *b*.

Mr. Wetherell found, along with *Pentacrinus subbasaltiformis*, in the London Clay near Highgate, the columns of a *Pentacrinite* with unequal joints, which he rightly regarded as distinct, and has figured under the above name.

The joints are more strongly angled than in the last; the angles very much rounded. Mr. Wetherell remarks, that there are two obscure tubercles on each of the larger joints. In one specimen there are two small joints between each large one. The articular surfaces are regularly five-lobed; the lobes rounded, with acute angles between them.

3. PENTACRINUS OAKESHOTTIANUS. (*See Woodcut*, p. 36.)

In Mr. Wetherell's extensive collection of Eocene Pentacrinite stems, there are several fragments of columns, which seem to have belonged to a different species from either of the two named kinds, and though small, appear to be distinct from young examples of *P. sub-basaltiformis*, which they most nearly resemble. The joints are equal, acutely pentangular, with a shallow groove between the angles. The articular surfaces are regularly stellate. In a portion of a column four tenths of an inch in length by one tenth in breadth there are twelve joints.

The specimens were found near Chalk Farm.

Genus BOURGUETICRINUS, *D'Orbigny*.

A genus of the Apicrinite group of Crinoids, having a slender column without ramules, and composed of graduated joints, with their articular surfaces plain, or marked by a transverse ridge, but never stellate. The summit of the stem is enlarged and pyriform, though small, and is composed of two sets of pieces. The cup is very shallow.

1. *BOURGUETICRINUS LONDINENSIS*. (*See Woodcut.*)

Mr. Wetherell has found fragments of a Crinoid in the London Clay at Copenhagen House, evidently belonging to a species of this genus. The joints are smooth, thick, elliptical, rounded and slightly swollen at either one or both their extremities, so as to present something of a dice-box shape. They are nearly equal, and their swellings alternate in an oblique manner. In the longest portion of a stem as yet discovered, measuring an inch and a quarter, there are ten articulations. Each of these is, at its broadest portion, one eighth of an inch in its widest diameter. The articular surfaces had a longitudinal ridge, in the manner of those of the chalk *Bourgueticrinus ellipticus*.

Much interest attaches to the discovery of this Crinoid. Hitherto the genus to which it belongs has been known from several species found in the chalk, one found in the Eocene tertiaries of Biaritz, and one still living in the seas of the Antilles, but of which, like that before us, the joints only are known. No British Eocene species had hitherto been discovered.



EXPLANATION OF THE FIGURES.

1. *SCHIZASTER D'URBANI*.—2 *a* and *b*. Column of *PENTACRINUS SOWERBII*; 2 *c*. Articular surface of joint.—3 *a* and *b*. Column of *PENTACRINUS OAKSHOTTIANUS*, magnified and of the natural size; 3 *c*. Surface of a joint.—4 *a* and *b*. Joints of the column of *BOURGUETICRINUS LONDINENSIS*; 4 *c*, joints magnified; and 4 *d*, an imperfect articular surface.

PLATE I.

ECHINODERMS OF THE CRAG.

Fig.

1. *TEMNECHINUS EXCAVATUS*, *p.* 6.

1*a.* Upper surface.

1*b.* Side view.

1*c.* Ambulacral and interambulacral plates and avenues.

1*d.* A spine.

2. *TEMNECHINUS MELOCACTUS*, *p.* 7.

2*a.* Upper surface.

2*b.* Side view.

3. *TEMNECHINUS GLOBOSUS*, *p.* 8.

3*a.* Upper surface.

3*b.* Side view.

3*c.* Ambulacral and interambulacral plates.

4. *ECHINUS LAMARCKII*, *p.* 2.

4*a.* Side view.

4*b.* Ambulacral and interambulacral plates, and avenues.

4*c.* A spine.

5. *ECHINUS LYEELII*, *p.* 4.

5*a.* Fragment showing ambulacral and interambulacral plates.

5*b.* A portion magnified.

5*c.* A spine.

6. *ECHINUS CHARLESWORTHII*, *p.* 5.

6*a.* Upper surface.

6*b.* Side view.

6*c.* Ambulacral and interambulacral plates.

7. *ECHINUS HENSLOVII*, *p.* 5.

7*a.* Upper surface.

7*b.* Side view.

7*c.* An interambulacral and two ambulacral plates.

Fig.

8—13. *ECHINOCYAMUS PUSILLUS*, *p.* 10.

8*a.* Upper surface.

8*b.* Under surface.

8*c.* Side view.

8*d.* Highly magnified.

8*e.* Spines magnified.

9. Another specimen, under surface.

10*a.* Upper surface.

10*b.* Side view.

11. Under surface.

12. Interior, dorsally.

13. Interior ventrally.

14. *ECHINOCYAMUS HISPIDULUS*, *p.* 11.

14*a.* Upper surface.

14*b.* Under surface.

14*c.* Side view of a variety.

15. *ECHINOCYAMUS PUSILLUS*, var. *ROTUNDUS*.

16. *ECHINOCYAMUS SUFFOLCIENSIS*, *p.* 11.

17, 18. *ECHINOCYAMUS OVIFORMIS*, *p.* 12.

19. *COMATULA BROWNII*, *p.* 19.

17*a.* Upper surface.

17*b.* Under surface.

17*c.* Side view.

20. *COMATULA WOODWARDI*, *p.* 19.

20*a.* Upper surface.

20*b.* Under surface.

20*c.* Side view.

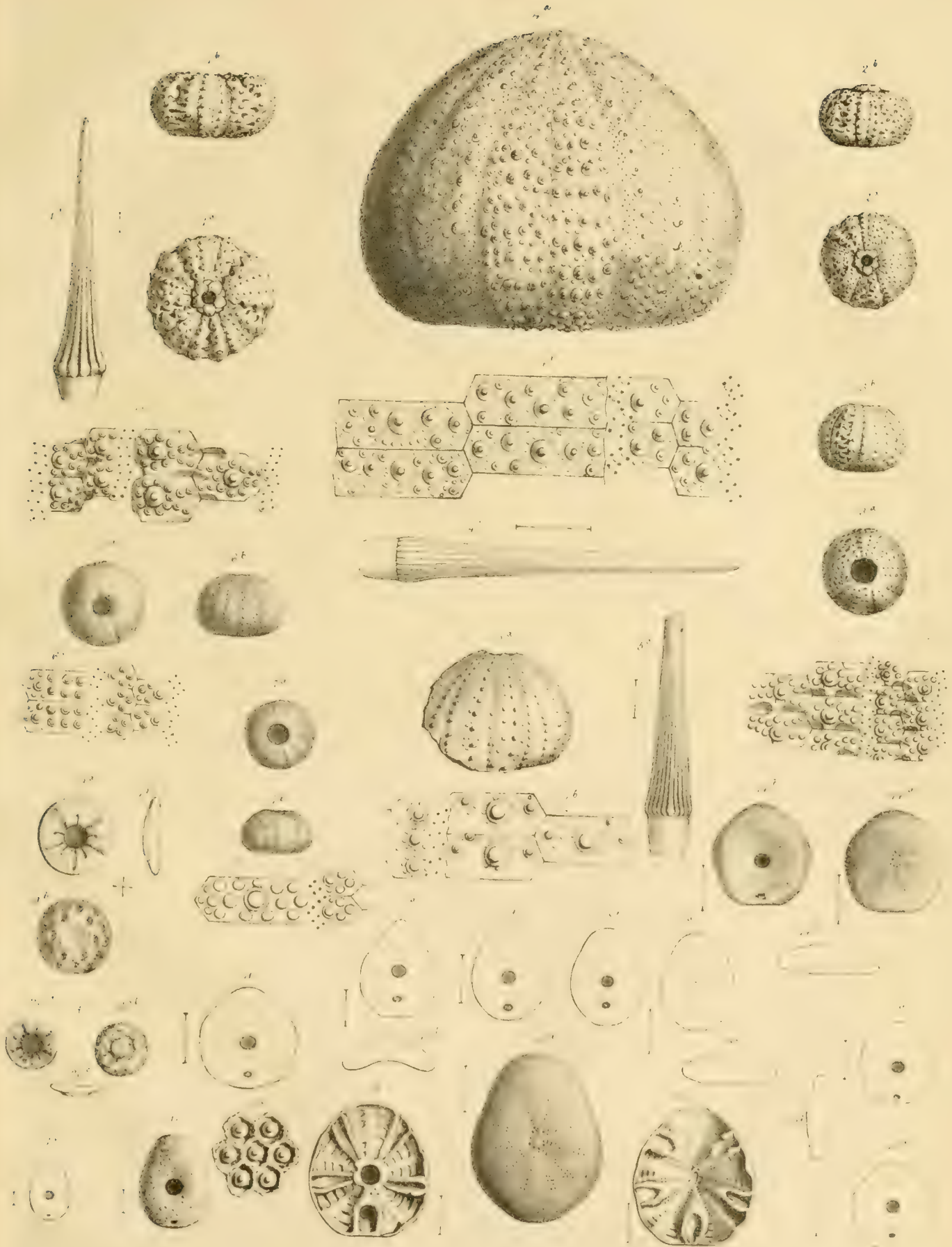


PLATE II.

ECHINODERMS OF THE CRAG.

Fig.

1. AMPHIDETUS CORDATUS, *p.* 16.

1*a.* Upper surface.

1*b.* Under surface.

2. SPATANGUS REGINÆ, *p.* 14.

3. SPATANGUS PURPUREUS, *p.* 13.

1*a.* Upper surface.

1*b.* Tubercles and spines.

4. BRISSUS SCILLÆ, *p.* 15.

1*a.* Upper surface.

1*b.* Caudal extremity.

1*c.* Fasciole, &c.

5 and 6. ECHINARACHNIUS WOODII, *p.* 12.

7. URASTER RUBENS, *p.* 17.

7*a.* Specimen entire.

7*b.* A portion enlarged.



PLATE III.

ECHINODERMS OF THE LONDON CLAY.

Fig.

1. *CÆLOPLEURUS WETHERELLI*, *p.* 24.

- 1*a.* Upper surface.
- 1*b.* Under surface.
- 1*c.* Profile.
- 1*d.* Profile magnified and restored.
- 1*e.* Genital disk.
- 1*f.* Specimen with spines.
- 1*g.* Spine, and magnified portion.

2. *ECHINOPSIS EDWARDSI*, *p.* 23.

- 2*a.* Upper surface of natural size.
- 2*b.* The same magnified and restored.
- 2*c.* Plates and pores.
- 2*d.* A primary tubercle.
- 2*e.* A spine.
- 2*f.* Portions of middle and extremity of spines.

3. SPINE OF *ECHINUS DIXONIANUS*, *p.* 22.

4. SPINE OF *CIDARIS WEBSTERIANUS*, *p.* 22.

5. *HEMIASTER PRESTWICHII*, *p.* 25.

- 5*a.* Upper surface.
- 5*b.* End view.
- 5*c.* Side view.
- 5*d.* Upper surface magnified and restored.

6. *HEMIASTER BOWERBANKII*, *p.* 24.

- 6*a.* Upper surface.
- 6*b.* Under surface.
- 6*c.* End view.

Fig.

7. *EUPATAGUS HASTINGLE*, *p.* 26.

7*a.* Upper surface.

7*b.* Anal extremity, showing the caudal fasciole.

7*c.* Portion of the odd ambulacrum.

7*d.* and *e.* Spinigerous tubercles.

8. *HEMIASTER BRANDERIANUS*, *p.* 28.

8*a, b, c.* Portions of the Barton variety.

8*d* and *e.* Example from Haverstock Hill, magnified and restored.

9. *SPATANGUS OMALII*, *p.* 28.

9*a.* Fragments from Barton.

9*b.* Restoration of upper surface.

9*c.* Tubercles and their areolæ.

ECHINODERMS OF THE CRAG.

10. *ECHINUS MELO*? *p.* 4.

11. *TEMNECHINUS TURBINATUS*, *p.* 8.

11*a.* Upper surface.

11*b.* Side view.

11*c.* Ambulacral and interambulacral plates.



PLATE IV.

ECHINODERMS OF THE LONDON CLAY.

Fig.

1. *ASTROPECTEN ARMATUS*, *p.* 29.

1*a.* Natural size of specimen.

1*b.* Marginal plates and spines, magnified.

2. *ASTROPECTEN CRISPATUS*, *p.* 29.

2*a.* Upper surface.

2*b.* Under surface.

3. *ASTROPECTEN* ? *COLEI*, *p.* 30.

3*a.* Specimen of natural size.

3*b.* Plates and spines.

4. *GONIASTER MARGINATUS*, *p.* 31.

5. *GONIASTER TUBERCULATUS*, *p.* 31.

5*a.* Natural size of fragment.

5*b.* A marginal plate magnified.

6. *GONIASTER STOKESII*, *p.* 30.

6*a* and *b.* Portions of rays.

6*c.* Marginal plates magnified.

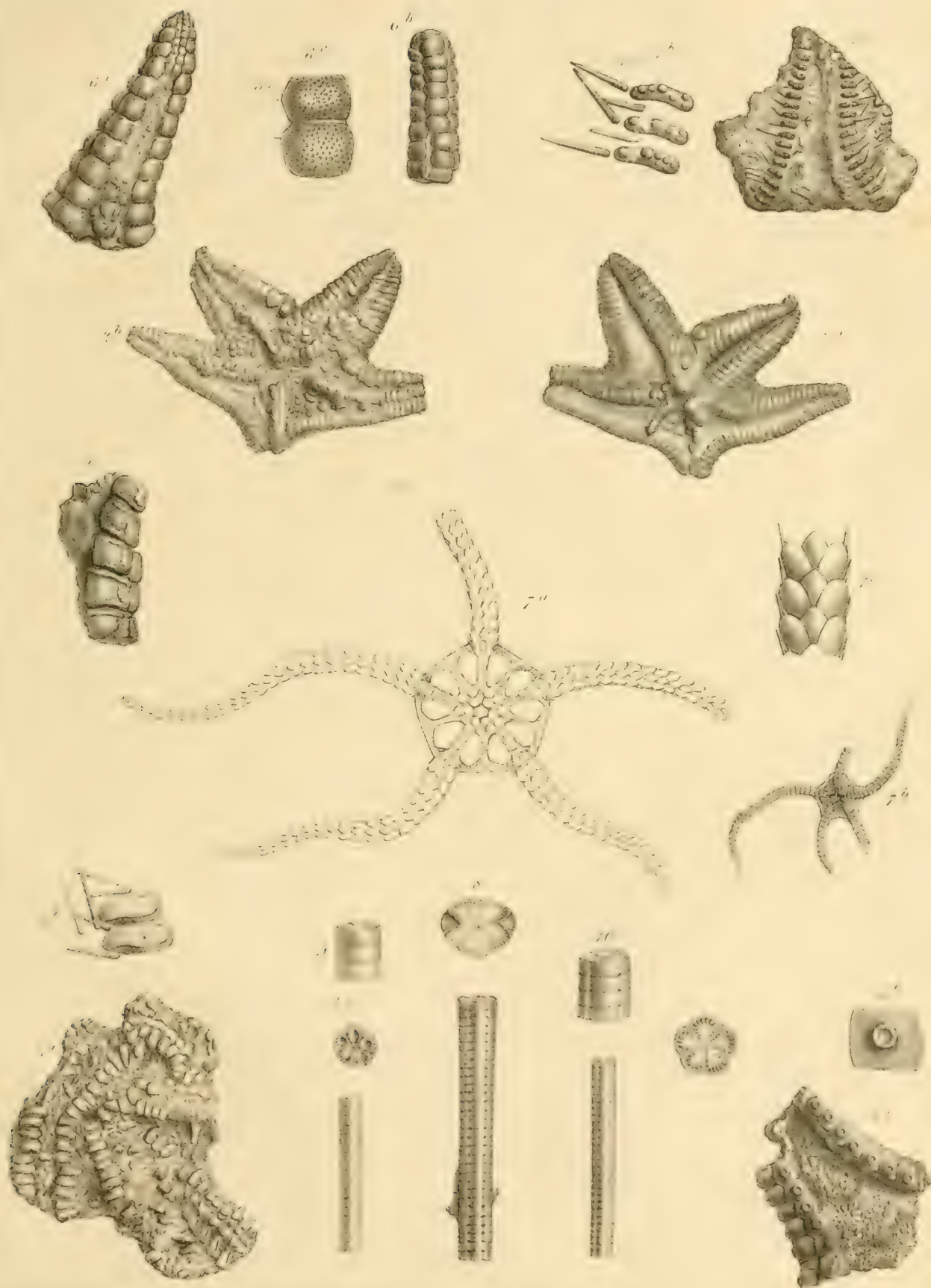
7. *OPHIURA WETHERELLI*, *p.* 32.

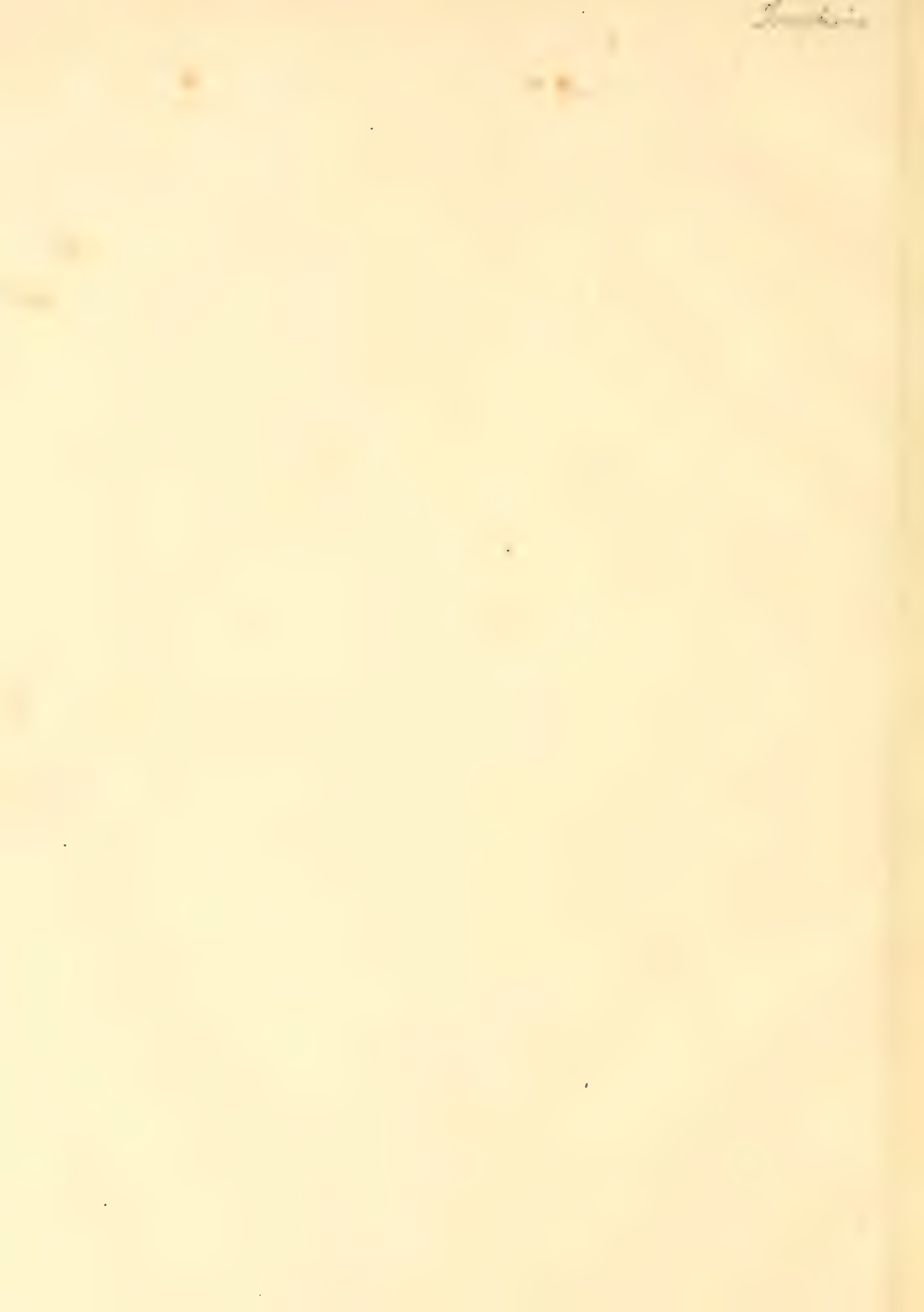
7*a.* Restoration.

7*b.* A specimen, natural size.

7*c.* Portion of the upper surface of an arm.

8,9,10. COLUMNS AND JOINTS OF *PENTACRINITES SUBBASALTIFORMIS*. *p.* 34.









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